Industrial process technologies—technologies that affect how companies produce goods and services—are critical to America's productivity. According to Jack Swindle, chairman of the National Center for Manufacturing Sciences (NCMS) Board of Directors, "All too often, American manufacturers fail to realize it's not what they produce, but how they produce it that determines customer satisfaction, sustained profitability, and long-term global competitiveness."[1]

Advanced technology allows U.S. manufacturers to improve their processes and techniques, and, in some cases, reduce the environmental impact of manufacturing. Revolutionizing U.S. manufacturing operations, these technologies can drive costs and cycle times down, while gearing productivity and quality up—important factors for companies that want to improve profitability and customer satisfaction.

And, as more companies integrate these technologies into their operations, the U.S. manufacturing industry gains a competitive advantage in the global marketplace. What types of technology are we referring to? Manufacturers can benefit greatly from innovations in everything from harder materials for stamping and punching to artificial intelligence software that can detect machine defects and react to unforeseen events.

Today's market. Manufacturing is the backbone of American industry, supporting about 47 percent of the Nation's total employment (17.8 million jobs in direct manufacturing and 34.1 million in secondary jobs) in 1993.[2] Real output for U.S. manufacturing, overall, is projected to grow at an average annual rate of 2.4 percent between 1992 and 2005. U.S. manufacturing's direct share of the economy accounts for over one-fifth of the gross domestic product, and nearly half of the total U.S. economic activity depends at least indirectly on manufacturing.[3]

Tomorrow's opportunity. To meet various needs for ballistic missile defense, BMDO has funded the development of advanced technology in neural networks, lasers, optics, and materials. While improving the Nation's defense, much of this technology also offers strategic benefits to the American manufacturing community, helping companies to significantly improve industrial capabilities. The following section describes eight of these innovations.

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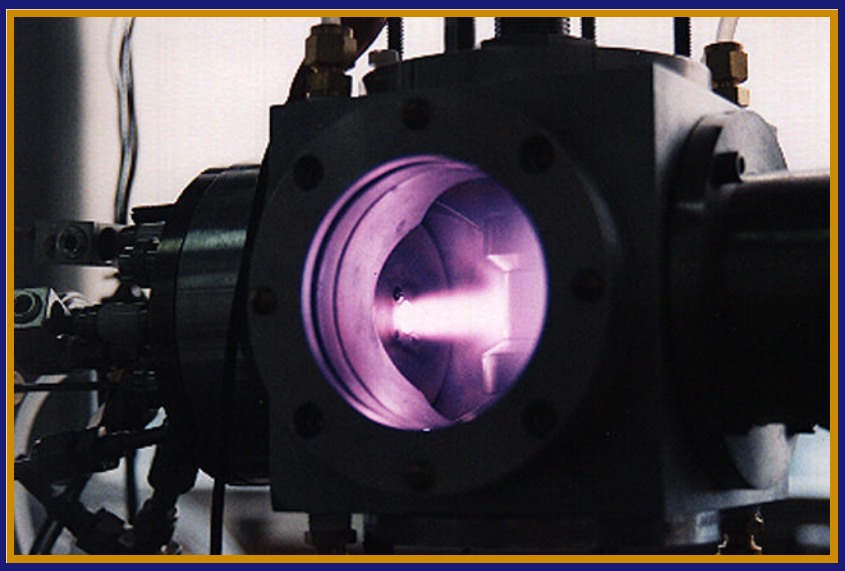
[1] Process Technologies Offer Strategic Benefits to American Manufacturing Community and the Nation…*Focus*, May 1995, p. 1.

[2] American Manufacturing Crucial to Job Development, Economic Prosperity of the Nation…*Focus*, March 1994, p. 1.

[3] U.S. Manufacturing: The Big Picture…*Focus*, January 1995, p. 8.



Jet Process Corporation,
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MANUFACTURING

Adaptive Optics May Save Millions For Manufacturers

In the early 1990s, the Department of Defense declassified a set of technologies called adaptive optics, which had been developed with considerable funding from BMDO. Adaptive optics were immediately recognized for their potential to help the astronomical community because they allow Earth-based telescopes to measure and correct optical distortions that atmospheric turbulence can cause.

But few people noticed the technology's potential for more terrestrial applications on the manufacturing floor—except a small firm called AOI International (Lowell, MA). Using adaptive optics technology developed for BMDO reconnaissance and scientific imaging systems, AOI is making automated optical inspection systems that can save manufacturers millions of dollars. This effort is being funded by the Advanced Research Projects Agency's Technology Reinvestment Project.

AOI IS DEVELOPING SYSTEMS THAT CAN SPOT FLAWS AS THEY OCCUR IN PRINTED CIRCUIT BOARDS, REDUCING THE COST AND WASTE FROM SCRAPPING FINISHED PRODUCTS.

AOI's systems are particularly attractive to the printed circuit board (PCB) industry, which annually throws away millions of dollars worth of finished boards because manufacturers cannot spot flawed PCBs before product completion. To improve manufacturing yields, PCB makers need inspection systems that can spot flaws as they occur.

Because AOI's adaptive optics can enhance the efficiency of PCB plants, the company believes its technology will give domestic manufacturers a competitive edge in world markets. And, while AOI is focusing its research on the sizable PCB manufacturing industry (which accounts for over half of the billion-dollar market for automated optical inspection systems), future markets also exist in the manufacture of food and wood products, cars, plastics, and pharmaceuticals.

Pictured above is a defect evaluation and repair station.

About The Technology

AOI International's innovations are based on a technology called shearing interferometry, a method for sensing the phase difference in wavefronts. With this information, adaptive optic systems can change the focal point of so-called rubber mirrors (mirrors made of a piezoelectric ceramic that change their shape in response to an applied voltage) to eliminate these phase differences and produce flawless images. BMDO funded this research to accurately track and destroy incoming missiles with high-energy laser beams.

In the adaptive optics systems developed for military and astronomical uses, shearing interferometry is used to measure the phase difference between a laser “guide star” (whose wavefront characteristics were known) and the object being imaged. AOI's interferometers measure the phase differences caused by changing process conditions during highly detailed and finely dimensioned manufacturing operations, so that the imaging system can adjust accordingly. As a result, AOI's inspection systems can continuously change focus, providing the dynamic image quality control needed to spot flaws during the manufacturing process.

Composites Meet Mass Production Requirements

MMCC has already produced automotive parts, such as the connecting rods pictured above.

No matter how good a product or material is, it will not be widely used commercially if it cannot be economically mass-produced. Such is the case with some of the strong, durable, lightweight cast composites developed for military use. While ideal for high-value parts in automobiles, aircraft, and even sporting goods, these materials are not widely used in consumer products because they cost too much to mass produce.

MMCC HAS PRODUCED CONNECTING RODS FOR FERRARI AUTOMOBILES AND IS ALSO DEVELOPING BRAKE CALIPERS WITH ALLIEDSIGNAL AND FORD MOTOR COMPANY.

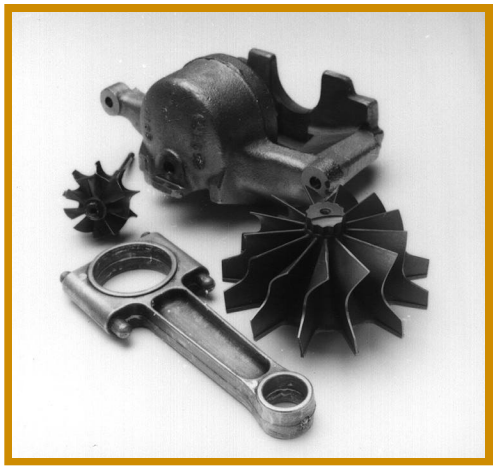
Metal Matrix Cast Composites, Inc., or MMCC (Waltham, MA), has developed a faster and more affordable way to manufacture high-strength, lightweight materials called metal matrix cast composites. The company's method could make production of these materials 25 times faster than current methods. Such speed dramatically lowers production costs and allows composite materials—which are stronger and lighter than steel—to be widely used.

BMDO originally funded this work at the Massachusetts Institute of Technology, or MIT (Cambridge, MA), to produce less expensive metal matrix cast composites for missile parts. A researcher at MIT later licensed the technology and formed MMCC to commercialize the process. MMCC has since received a BMDO SBIR contract to continue this work.

So far, MMCC has used its expertise to produce connecting rods for Ferrari automobiles and is developing brake calipers with AlliedSignal and Ford Motor Company. MMCC has also used the technology to manufacture electronic packaging components and heat sinks for commercial and military applications.

Metal matrix components offer advantages over their heavier steel counterparts because they retain their strength under high temperatures and yet can be cast into complex shapes for specialized uses. MMCC's casting process is expected to increase stiffness and improve thermophysical properties over conventionally cast reinforced structural components with little increase in cost. The process will also strengthen unreinforced cast components through its complete material flow into mold spaces and its accurate control of the mold cooling process.

MMCC uses low-cost molds, which lend themselves to rapid prototyping of cast components. Wet and dry friction performance or built-in lubricity materials can be molded using MMCC's process, and resulting components require little followup finishing, even for high-tolerance parts.



Pictured above are a brake caliper, rotors, and a connecting rod. The brake caliper and connecting rods have been manufactured using MMCC's process. MMCC plans to eventually make rotors.

About The Technology

MMCC's method does not require a vacuum pressure vessel surrounding the mold or furnace; it uses a pressure vessel only for pressurization and infiltration of the melt, while cooling is controlled to enhance directional solidification. The process usually takes only about 10 minutes depending on the amount of material used and its composition. Therefore, items can be cast faster, and composites are more completely bound by the matrix. Tightly controlled cooling results in accurately shaped complex parts with desired grain orientation, boundary conditions, and surface control.

MMCC has an exclusive worldwide, all-fields-of-application license for the pressure infiltration process and related tooling materials, and it has filed patents in North America, Europe, and Asia.

Intelligent Software Reacts To Unforeseen Events

Although computer automation has revolutionized the factory floor, the complex control systems that have evolved to handle this automation are anything but flexible. Most control systems have been designed to handle predetermined situations, and are paralyzed when confronted by an unplanned event. A mainframe-controlled system seeks direction from its central source on how to handle anything that seems abnormal; after a period of time the central source provides a solution to the control system's dilemma. This top-down approach can drastically slow down processes—leading to lost money because of lost time—and sometimes can even cause complete system failures.

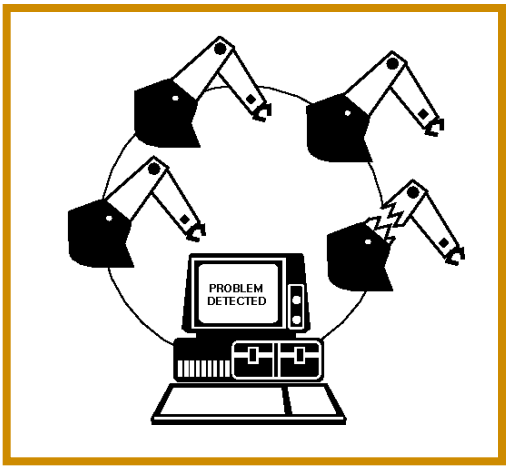
Intelligent Automation's software decreased system failures from several a day to almost none.

Intelligent Automation, Inc., or IAI (Rockville, MD), is developing a more efficient bottom-up approach for controlling complex systems such as those used in manufacturing. The basis of its technology is BMDO SBIR-funded software originally designed for better battle management. Called autonomous agents, IAI's systems quickly react to unforeseen events by permitting moment-to-moment intelligent decision making at the equipment level.

The National Center for Manufacturing Sciences and the National Institute of Standards and Technology are providing technical support to IAI's research efforts. These organizations are pursuing autonomous agent technology to improve productivity, quality, accuracy, and speed of shop floor equipment.

In addition to optimizing overall system performance, IAI's autonomous agents can be used to allocate resources and schedule production at large factories. Decreasing system failures from several a day to almost none, IAI's system has already replaced existing computer programs to control and schedule painting in a vehicle painting facility. IAI has also teamed with Flavors Technology (Manchester, NH) to test autonomous agent technology in factory scheduling.

IAI was recently awarded an Advanced Research Projects Agency contract to develop autonomous agent technology for dependent schools overseas run by the Department of Defense. In this application, the technology can be used to search for educational materials (text, audio, and video) on the Internet quickly and efficiently. By selecting material that meets the specific needs of individual students, this project is expected to improve the quality of the children's education significantly while lowering its cost.



IAI's technology quickly reacts to unforeseen events by permitting moment-to-moment intelligent decisionmaking at the equipment level.

About The Technology

Autonomous agents use the science of emergent behavior (or chaos theory) to control applications whose variables linger between random and predetermined states. Today's central control systems try to predict all possible events and develop responses to each. However, small unforeseen errors or undescribed events can lead to major operation slowdowns or total system crashes. Agent-based systems offer robustness and agility by establishing intelligent decisionmaking at the local level. By making moment-to-moment control decisions at this level, autonomous agents can decrease a system's vulnerability to unforeseen problems.

IAI's initial experiments using computer simulations suggest that autonomous agents can help control the sometimes unpredictable behavior of complex systems used for military applications such as battle management. The company is currently increasing the data output of the simulations and expanding the size and variety of engagements simulated.

Neural Networks Ease Machine Distress

The National Center for Manufacturing Sciences worked with NETROLOGIC to develop a way to detect machine defects in industrial presses, such as the one pictured above.

Even with the best maintenance, heavy industrial machinery occasionally breaks down when it is operated for a long time under rugged conditions. Downtime on the typical machine shop floor ranges from 10 to 30 percent and can be very costly; failures can cost the manufacturer upwards of $150,000[4]—and can be as much as $500,000.

But manufacturers of automobiles and heavy equipment now have new insight into the symptoms of machine trouble. They know that a machine will give forewarning of its impending failure. The trick is to recognize these signs in the earliest stages so that the machine can be serviced before vital components are damaged. Early diagnosis reduces the cost of major repairs and increases the life of the machine.

General Motors and the National Center for Manufacturing Sciences joined forces with researchers at NETROLOGIC, Inc. (San Diego, CA), to develop a way to detect machine defects in industrial presses. They are using BMDO-funded algorithms to reduce the typical 10 to 30 percent downtimes to less than 5 percent.

The team is using a method called wavelet signal processing, which extracts information from signals that indicate defective machinery. Part of this development includes BMDO-funded research conducted at NETROLOGIC for neural network programming and genetic algorithms used for improved target acquisition and surveillance. Wavelet and neural network signal processing algorithms can sort out abnormal vibrations from the chaos of normal machine operation. Efforts are under way to commercialize the technology so that it can be used in related heavy industries.

NETROLOGIC USES BMDO-FUNDED NEURAL NETWORK RESEARCH TO RECOGNIZE MACHINE STRESS AND HELP PREVENT COSTLY REPAIRS AND DOWNTIME.

NETROLOGIC has consulted with General Electric in the use of neural network-based determinations for inertial weld joint quality. The two companies have also collaborated in training for the use of parallel processing. NETROLOGIC continues related research sponsored by the Department of Education, the Navy, the Air Force, the National Aeronautics and Space Administration, the Advanced Research Projects Agency, the National Center for Manufacturing Sciences, and others.

About The Technology

In genetic algorithms and neural processing, a system operator selects a set of variables that measure the state of a complex system. After the system's initial state parameters are processed, a new set of parameters is generated that can be used as input for a new iteration. This process is repeated until an optimal set of parameters is reached, and the system is said to have "learned" the solution. NETROLOGIC's wavelet signal processing algorithm serves as a feature extractor front end for such information processing. The algorithm is analogous to a Fourier transform; it recognizes short-lived signals, or wavelets. The wavelets are "time signatures" that occur in a nonsteady-state manner. When compared with a baseline signature, they can be used to determine the state of the machine under scrutiny.

The use of neural networks and genetic algorithms has long been associated with artificial intelligence. Other applications include data compression, pattern recognition, real-time machine diagnostics, robotics, seismic signal detection, and real-time process control.

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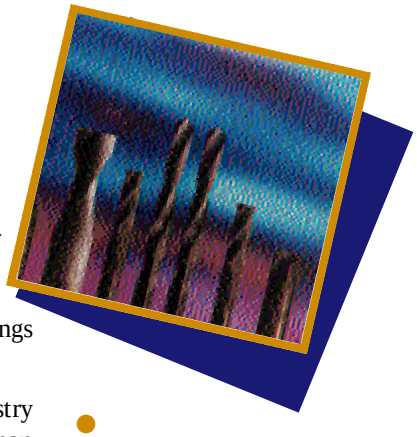
[4]Process Technologies Offer Strategic Benefits to American Manufacturing Community and the Nation… *FOCUS*, National Center for Manufacturing Sciences, May 1995, p. 5.

Diamond-Coated Tools Cut Through Commercial Barriers



Crystallume is leading a consortium to coat rotating tools such as drills, reamers, and end mills with its DCC® materials.

Since the mid-1980s, many entrepreneurs have dreamed of getting rich by selling new diamond products such as diamond-coated cutting tools for manufacturing and innovations for better performing microelectronics. A study conducted by Jim Russell, editor of *Diamond Depositions Science and Technology*, estimated that the total market for diamond thin-film coatings in 2020 will be at least $5 billion.

Although 2020 may seem like a long time in the future, the beginning of a commercial industry for diamond coatings is visible now. For example, Crystallume (Santa Clara, CA) raised more than $5 million in an initial public offering in 1994 to commercialize its diamond-coated products. The company received substantial early funding in diamond R&D from the BMDO SBIR program.

Crystallume's products include a new line of DCC® (diamond-coated tungsten carbide) cutting tools. These tools have been in great demand for cutting nonferrous materials—materials such as aluminum, often used to make automobiles and aircraft. Diamond cutting tools wear slowly, exhibit high lubricity, and do not heat-distort the workpiece. According to figures released by Crystallume, these products could capture as much as $450 million of the $8-billion-per-year cutting tool market.

CRYSTALLUME HAS OPENED A NEW MANUFACTURING FACILITY AND IS SCALING UP TO ECONOMICALLY COAT CUTTING TOOLS WITH DIAMOND.

Crystallume has overcome two major obstacles to bring its DCC® cutting tools to market. First, in a research project sponsored by the National Center for Manufacturing Sciences, the company solved the adhesion problems traditionally associated with diamond deposition on cemented carbides. Second, the company opened a new manufacturing facility, scaling up to coat cutting tools economically. This facility gives Crystallume a significant lead over competitors who cannot mass-produce diamond products.

Crystallume also markets a diamond-coated pad that spreads heat away from high-power electronic devices. And it has several products on the horizon. For example, Crystallume is leading a consortium funded by the National Institute of Standards and Technology's Advanced Technology Program to coat rotating tools such as drills, reamers, and end mills with its DCC® materials. This consortium also includes General Motors, Ford Motor Company, Boeing, Hughes Missile Systems, and Rogers Tool Works.

In addition, the company has recently coated silicon nitride ceramic ball bearings with diamond, which provides an ultrahard, low-friction, and chemically resistant surface for high-performance military and commercial machinery. And, working with a major automotive company, Crystallume is coating engine components with diamond to improve wear resistance.

About The Technology

Diamond is twice as hard as its natural competitor, boron carbide. It also has an electrical resistivity ten times that of alumina, a thermal conductivity five times that of silver, and a coefficient of friction equal to or better than that of Teflon®. Diamond is also inert to most corrosive chemicals.

Unlike natural and synthetic diamond stones, diamond films allow engineers to exploit all of its properties. Researchers have developed many different methods for producing these thin-film coatings, most of which are a variant of the original chemical vapor deposition (CVD) processes developed by Russia in the 1970s. In CVD processes, hydrocarbon gas and atomic hydrogen are mixed in a high-temperature, low-pressure reaction chamber and energized. The form of energy is what differentiates CVD processes. For instance, plasma-enhanced CVD—most often used at Crystallume—energizes a plasma local to the substrate surface using radio waves.

Lasers Find New Markets In Micromachining

A micrometer (or micron), one-millionth of a meter, is less than the width of a hair. Imagine having to produce microscopic structures that must be this precise, whose wires, holes, or shape cannot deviate more than one- or two-tenths of a micrometer. But, as high-tech products and their components get smaller and more detailed, that is exactly what some manufacturers must do. Micromachining, a relatively new process for manufacturing small parts, addresses this requirement. It is so accurate, it can cut and drill objects with submicron precision.

Potomac Photonics, Inc. (Lanham, MD), has entered the relatively new market for such manufacturing tools with a micromachining product called Laser MicroTools™. This tabletop workstation, based on BMDO-funded research in short-wavelength ultraviolet lasers, houses lasers with computer-integrated motion control and video imaging, and can pattern, mark, or shape a variety of materials into two- and three-dimensional structures. Since its commercial products hit the street in 1988, Potomac Photonics' commercial revenues have increased from 5 to 50 percent of its total business.

POTOMAC PHOTONICS' LASER MICROTOOLS™ HAS GREATLY CONTRIBUTED TO THE COMPANY'S COMMERCIAL SUCCESS.

Laser MicroTools™ can be used for a wide range of industrial applications. For example, they can repair semiconductors by opening shorts between conductors, so that defective computer chips can be repaired rather than scrapped. And they can drill tiny holes precisely, a task sometimes required for composite material applications. They are also useful for many medical applications, including eye surgery and tissue welding.

Laser Microtools™, pictured above, can be used to repair semiconductors and to process natural and synthetic diamond. The tabletop workstation can pattern, mark, or shape a variety of materials into two- and three-dimensional structures.

In addition, Potomac Photonics has been using the tools to process natural and synthetic diamond, forming a miniature gear in the surface of a diamond substrate. The company's ultraviolet lasers may be the key to allowing diamond-based mechanical and electronic systems to reach commercial markets. Other mechanical attempts to shape and polish diamond have been slow and cumbersome at best.

BMDO funded work in ultraviolet excimer lasers through its SBIR program to develop sensors with higher resolutions and better capabilities for processing materials. Potomac Photonics has also received related SBIR contracts from the National Science Foundation, the Air Force, and NASA.

About The Technology

In many laser applications, the shorter the wavelength the better. Shorter wavelengths provide better resolution, allowing lasers to write smaller circuits onto semiconductor materials or to detect targets better. Excimer lasers used in Laser MicroTools™ produce short-wavelength, ultraviolet beams. They usually require large power sources and offer low repetition rates, both of which are constraining to production environments.

Instead of pumping the laser with electrical pulses, a technology that requires large power sources, Potomac Photonics' lasers are pumped with electrodeless microwave discharges. This pumping method saves space not only by using a smaller power supply but also by requiring less lasing gas for sustained operations. Potomac Photonics' excimer lasers also provide repetition rates of up to 2,000 hertz, versus 100 to 500 hertz for other excimer lasers, providing faster processing and allowing the lasers to machine three-dimensional structures.

R&D Targeted To Lower Costs For Semiconductor Manufacturers

Manufacturers in the microelectronics and optical communications industries are constantly looking for ways to improve their high-speed, high-performance systems. With fierce competition both domestically and abroad, the manufacturers not only require high-tech components and materials, but also affordable processes to cheaply and safely mass-produce their new approaches.

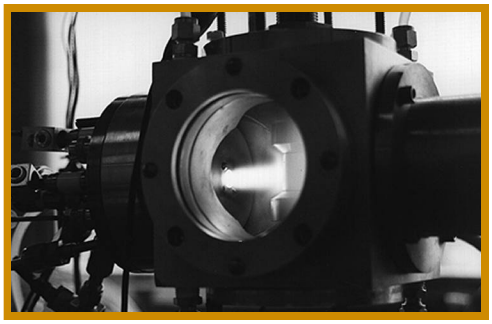
Jet Process Corporation (New Haven, CT) has developed a simple, low-cost, and environmentally friendly process called Jet Vapor Deposition, or JVD™, that can deposit high-quality coatings of many materials on almost any substrate. This enabling technology will allow manufacturers in the microelectronics and optical communications industries to mass-produce new generations of high-speed equipment. Such uses for JVD™ are transforming Jet Process from a custom fabricator of thin-film materials to a major player in the materials manufacturing business.

USING JVD™, JET PROCESS CORPORATION HAS TEAMED WITH OLIN CORPORATION AND GENERAL MOTORS TO DEVELOP AN ENVIRONMENTALLY BENIGN ALTERNATIVE TO ELECTROPLATING.

"In the short term," explains Jerry Schmidt, president of the company, "Jet Process is marketing custom JVD™ 'toll coating' manufacturing services to companies such as AT&T. Jet Process plans to further develop and market the JVD™ process through joint venture and licensing agreements with major U.S. manufacturing companies."

These plans have, in part, already begun to come to fruition. Using JVD™, Jet Process is working on a cost-shared project with Olin Corporation and General Motors' Packard Electric Division to develop an environmentally benign alternative to electroplating for electronics manufacturing. This project is sponsored by the Advanced Research Projects Agency.

Several Government R&D contracts, including two BMDO SBIR contracts to develop advanced semiconductor and optical materials, have helped the company. With BMDO funding, Jet Process has developed a low-cost way to make nonlinear optical materials—materials expected to form the foundation of emerging high-speed optical switching and information processing systems. Nonlinear optical materials react with different optical effects when subjected to different intensities of light, a capability that conventional optical materials lack. But they are very costly and difficult to produce in quantity. Jet Process' JVD™ technology can handle the complexity of making these components affordably and in mass quantities.



JVD™ can deposit many types of material coatings on almost any substrate. It features, among other benefits, relatively low equipment and operating costs and high deposition rates.

The company is also using JVD™ to make silicon nitride films for insulators, used in many semiconductor devices. Silicon nitride is better than the dominant insulator, silicon dioxide, because it can provide twice the barrier to current flow, allowing manufacturers to use thinner films and pack more circuitry into less area. But despite its advantages, silicon nitride has not been widely used because it is more difficult than silicon dioxide to deposit on silicon-based devices. Now Jet Process' JVD™ is being targeted to solve this problem for the microelectronics industry. The company has also used JVD™ to make coatings that have improved the performance of batteries, jet engine components, and composite material (just to name a few).

About The Technology

The JVD™ process uses sonic jets of high-purity inert gas, operating at ambient temperatures and in "low vacuum," to transport the coating vapor onto a variety of substrates, resulting in high-quality thin films. The patented process features lower equipment and operating costs than other deposition methods and pollution-free operation. It has high deposition rates (up to 1 micrometer per minute over a 1,000 cm^2), fast turnaround times, and a 90 percent material conversion efficiency.

Ionwerks' Measure Of Success Is Better Materials

Ionwerks (Houston, TX) is selling three new products that fill an important need in materials production. Its products, which monitor the growth of thin films, address a small market mainly represented by research institutions. Researchers using Ionwerks' products will be able to learn more about wide-bandgap materials such as diamond, gallium nitride, and silicon carbide used in modern electronics and electro-optical systems. They can then pass this information on to manufacturers so that new products using these materials can be mass-produced.

> IONWERKS' NEW PRODUCTS WILL ENABLE RESEARCHERS TO MAKE A NEW CLASS OF MATERIALS THAT CAN BE USED IN EVERYTHING FROM JET ENGINES TO ELECTRONICS.

The exceptional properties of wide-bandgap materials will allow manufacturers to make new commercial products in such areas as machine tools, electronics, optics, and even jet engine components. For example, the materials can be used to make more durable cutting tools, lower friction machinery, better corrosion protection coatings, and better heat dissipation designs for electronic components. Ionwerks' products will provide the research tools instrumental in developing processes to make these materials.

But before wide-bandgap electronics can be commercialized, researchers need to learn more about how these materials grow. BMDO—interested in wide-bandgap electronics to meet the high-power, high-frequency, high-temperature electronic system demands of ballistic missile defense—awarded two SBIR contracts to Ionwerks to develop advanced monitoring equipment.

Pictured above is Ionwerks' analysis tool that can be used to study the growth of wide bandgap materials.

Several collaborative efforts illustrate payoffs for Ionwerks' innovations. For instance, IBM Yorktown Heights has used one of Ionwerks' products—an analysis tool based on mass spectroscopy of recoiled ions (MSRI)—to understand in detail the thin-film growth mechanisms of several wide-bandgap materials; the team's findings have allowed IBM to produce some of the highest quality films to date. Ionwerks has also completed a 1-year cooperative research and development agreement with Argonne National Laboratory to study MSRI's process control applications. Because of this project, a major aerospace company is interested in using Ionwerks' MSRI to detect impurities in thermal shock barriers during protective coating deposition of jet engine turbine blades. Argonne National Laboratory and SI Diamond Technology, Inc. are also using Ionwerks' MSRI to monitor the growth of diamond thin films.

Since its first sale of hardware and electronics for MSRI in 1993, Ionwerks has released two more products: a time-to-digital converter (TDC) and a fast x-y detector. Both instruments can be used in many charged particle detection schemes. The TDC records time-of-flight measurements of a particle's kinetic energy, and the fast x-y detector quickly and accurately measures a particle's point of impact. These two devices together can measure position and time at speeds and accuracies previously unobtainable. They can also be used for laser radar sensing and imaging devices.

About The Technology

Mass spectroscopy of recoiled ions measures the elemental composition of thin-film surfaces as they grow. This feature—which results from MSRI's ability to operate at typical wide-bandgap material growth conditions (i.e., pressures around 10 milliTorr) and not at the high-vacuum conditions (around 10^{-6} Torr) required by other techniques—enables researchers to monitor a film's properties layer by layer as it grows. MSRI can also distinguish among ions of similar mass while causing almost no surface damage and can analyze dopant concentrations during and after growth. Ionwerks' other products also offer many advantages. The TDC provides 10 times better resolution and 10 times faster readout rates than older technologies. It also costs 15 percent less and features four channels (versus one in others). The fast x-y detector can measure an ion's point of impact at a resolution of less than 0.5 mm and with a readout rate 100 times faster than competing technology.